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Trade-offs between ecosystem services in managed and abandoned semi-natural grasslands

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Abstract

The effect of abandonment of sheep grazing management in semi-natural grasslands were studied in 14 sites in Norway. Data of species and vegetation composition, functional traits and pollination resources were used as indicators for nine selected ecosystem services (ES). The majority of the ES were negatively affected by abandonment of sheep grazing management. We therefore conclude that abandonment diminishes delivery of ES.

Keywords: grazing, supporting, regulating, provisioning, cultural, land use change

Introduction

Ecosystem services (ES) are the benefits humans obtain from nature (Millennium Ecosystem Assessment, 2005). Agricultural landscapes include mosaics of fields and grasslands ranging from monocultures to species rich semi-natural grasslands. Management of the semi-natural grasslands are relatively low intensive land use practices. The energy inputs are low but semi-natural grasslands provide multiple ecosystem services (ES); e.g. biomass, pollination, pest control, genetic resources, water quality, soil structure and cultural services such as recreation, aesthetics and tourism (Bullock *et al.*, 2011). The ongoing process of abandonment of extensive land use will influence provision of ES but little is known about the direction of these changes. The aim of this project is to assess potential effects of abandonment on ES in semi-natural grasslands in boreal ecosystems.

Materials and methods

Several studies have identified relations between vegetation characteristics and ecosystem services. Based on literature (De Bello *et al.*, 2010; Ford *et al.*, 2012; Pakeman, 2014; Vinge and Fløe, 2015), we identified 13 ES indicators that can be calculated from terrestrial plant data (Table 1). We recorded all vascular plant species and vegetation structure in 112 subplots (4 m^2) in managed (sheep grazing) and abandoned semi-natural grasslands in 14 sites in West and Mid Norway. In addition, data on functional traits and plant species as allergy inducing pollen providers or resources for pollinators were extracted (LEDA; TRY; the Biological Records Centre's database of insects and their food plants; the Norwegian asthma and allergy association). Functional diversity was calculated using the R-package FD (Laliberte *et al*, 2014). The ES indicators were transformed into notations between zero and one using negative (abundance of allergy, cover of canopy and shrub layer, community weighted mean of leaf dry matter content) or positive linear transformation (the remaining indicators). The indicators are related to one or several ES and for each ES a bundle of indicators reflect the value of the ES. We therefore aggregated the indicators of each ES using weighted mean values of the notations. Then to assess the potential changes in ES due to abandonment, we compared the aggregated values of the ES in the managed and the abandoned semi-natural grasslands using linear mixed models (site as random). All analyses were done in the R software (R Core team, 2015).

Results and discussion

Our results show that grazing management generally has a positive effect on the deliverance of ES (Figure 1). The values of the supporting services nutrient cycling and genetic resources, the provisioning

Table 1. Ecosystem services (ES), indicators, and data. ES indicators: number of (NUMBER) plant species and flower colours, abundance of (ABUN) graminoids, legumes, herbs, allergy-inducing pollen producers (allergy), plant species attractive for *Hymenoptera* (Hymenopteran) and butterflies (butterfly), cover of (COVER) canopy and shrub layer, community weighted mean of (CWM) specific leaf area (SLA), leaf dry matter content (LDMC) and leaf nitrogen content (LNC) and functional richness of (FR) LDMC.

ES category	ES	Indicator	Data
Supporting	Nutrient turnover	ABUN legumes	Species composition
		CWM LDMC	Functional diversity
		CWM SLA	Functional diversity
	Allergy control	ABUN allergy	Species composition
	Genetic resources	NUMBER species	Species composition
Regulating	Pollination	ABUN butterfly	Species composition
		ABUN Hymenopteran	Species composition
Provisioning	Forage quantity	CWM LDMC	Functional diversity
		CWM SLA	Functional diversity
	Forage quality	CWM LNC	Functional diversity
		ABUN graminoids	Species composition
	Forage stability	FR LDMC	Functional diversity
Cultural	Aesthetics	ABUN herbs	Species composition
		NUMBER flower colours	Functional diversity
	Attractiveness	COVER canopy layer	Vegetation structure
		COVER shrub layer	Vegetation structure

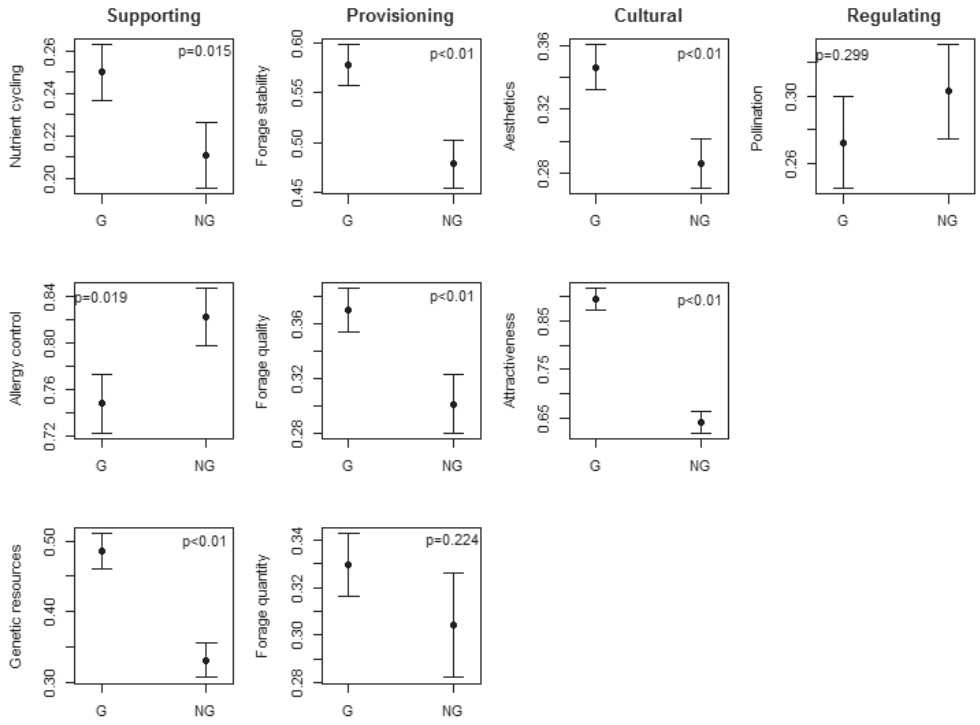

Figure 1. Mean and standard error of ecosystem services (supporting, provisioning, cultural and regulating) in grazed (G) and abandoned/not grazed (NG) semi-natural grasslands. *P*-values are based on likelihood ratio chi-square tests of mixed linear models.

services forage stability and quality, and the cultural services aesthetics and attractiveness were all higher in the managed semi-natural grasslands compared to the abandoned ones. Allergy control on the other side was highest in the abandoned grasslands. Different management regimes favour different ES (Ford *et al.,* 2012) and trade-offs need to be taken into account in conservation practices. Abandonment of grazing management in semi-natural grasslands results in encroachment and succession toward forest (Wehn *et al.,* 2011). Semi-natural grassland is a threatened nature type and its biological value is decreasing (Norderhaug and Johansen 2010), but this study show that semi-natural grasslands should be conserved also for supporting, provisioning and cultural ecosystem services.

Conclusions

Abandonment of management in semi-natural grasslands reduces the delivery of multiple ES.

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